IMPACT ON RAINBOW TROUT REPRODUCTION ASSOCIATED WITH THE ATTAINMENT OF THE RECREATIONAL POOL ELEVATION AT MYSTIC LAKE

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Final Draft

November 1, 1984

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ABSTRACT

Mystic Lake is located in the West Rosebud Creek drainage in Stillwater County, Montana. In 1983, the Montana Power Company was granted a 1-year variance to their FERC license to delay filling Mystic Lake to the recreational pool elevation (7,663.5 ft.) from July 1 to July 10. The purpose of the delay was to generate additional power during the month of June. A study of the impact the delay of fill had on rainbow trout spawning activity and large zooplankton development was documented in 1983. In 1984, a comparable study was conducted when the recreational pool elevation deadline was July 1.

Spawning rainbow trout were confronted with similar low-pool conditions initially and subsequent rising water levels as the lake neared the recreational pool elevation in both years. Three major spawning areas were located in the west end of the lake: in the West Rosebud full-pool inlet, in Creek #10 above the full-pool elevation and in the low-pool confluence area of Huckleberry and West Rosebud creeks. Use of all three spawning areas was similar in both years. Attainment of the recreational pool elevation did not affect water levels in the West Rosebud full-pool inlet and in Creek #10 in both years.

The Huckleberry-West Rosebud confluence area was inundated with lake water prior to attaining the recreational pool elevation in 1983 and 1984. During the egg incubation period, this area was under 25.6 ft. of water in 1983 and 24.5 feet in 1984. Spawning activity ended once flooding of this area occurred. Twenty-three percent of the rainbow trout eggs in the incubation stations in this area hatched. Intergravel dissolved oxygen was adequate throughout the incubation period.

The zooplankton development period was similar in both years. Rainbow utilized this food source in late August after the spawning period when the fish returned to their lentic environment.

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INTRODUCTION

Prior to 1926, Mystic Lake was a natural body of water occupying 342.5 acres. In 1926, Montana Power Company (MPC) built a dam, adding approximately 104.15 surface acres of additional water storage. MPC's FERC license (FPC No. 2301) requires the reservoir be filled to the recreation level (7,663.5 ft.) by July 1. In 1982, MPC filed a one-year variance to their FERC license to delay fill to the recreation level from July 1 to July 10, 1983. Under the existing refill date, power generation was lost in some years because reduced generation in June was necessary to refill the reservoir by July 1. MPC's application for the delay of fill states that extending the refill date to no later than July 10 approximately 3,900 megawatt hours of additional generation was expected during the refill period in 1983.

This study was initiated in response to Montana Department of Fish, Wildlife and Parks' (DFWP) concern that the delay of fill could affect rainbow trout (Salmo gairdneri) spawning movement into tributaries and interfere with the life cycle of two large zooplankton species (Diaptomous shoshoni) and (Holopedium gibberum) thought to be an important food source to rainbow trout (Marcuson, 1982).

Due to the particular hydrological conditions in 1983, DFWP, MPC and FERC agreed to delay filling the reservoir from July 1 to July 10, and the impact on the rainbow trout fishery was documented (Schollenberger 1983). In 1984, MPC complied with the July 1 refill date. A comparative study between the 2 years was conducted and is presented in this report. The MPC provided funding for this 2-year study.

OBJECTIVES

1. Locate major rainbow trout spawning areas and determine accessibility of those areas at various lake elevations.

2. Determine the duration of the spawning period.

3. Monitor the effects of increasing lake levels on low-pool spawning areas.

4. Document the development sequence of the two large zooplankton species.

STUDY AREA

Mystic Lake is located on West Rosebud Creek in Stillwater County approximately 90 miles southwest of Billings, Montana, and is surrounded by the Absaroka-Beartooth Wilderness on three sides (Figure 1). A three-mile hiking trail through non-wilderness U.S. Forest Service (USFS) lands provides access to the lake. Mystic is one of the most heavily used recreation areas in the Absaroka-Beartooth Mountains. A recreational study conducted by MPC in 1983 from July 1 to July 10 estimated 32 people per day visited the Mystic Lake area. Their main objective was to fish (MPC, 1983).

Mystic Lake is also the largest lake in the A-B Mountains. At full-pool elevation of 7,673.5 ft., the lake occupies 446.65 acres (Figures 2 and 3). Surface area of the lake can be reduced approximately one-third and depth of

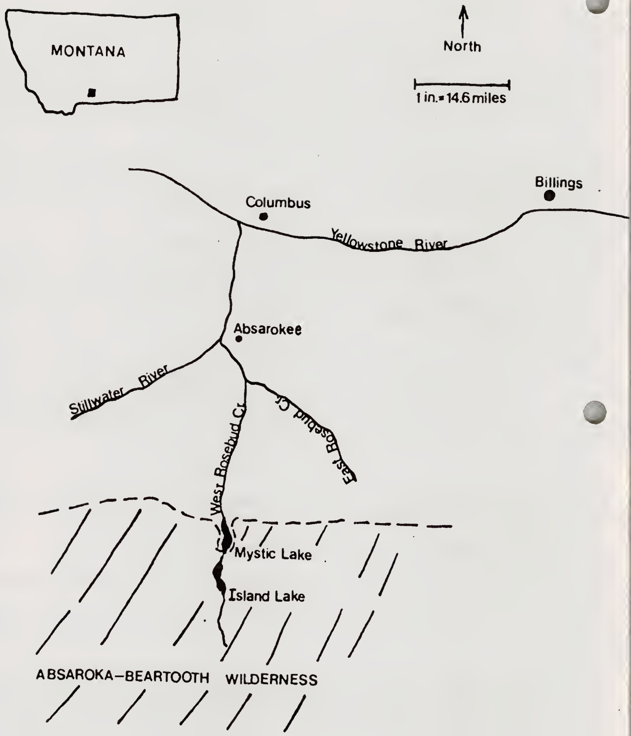

Figure 1. Map of West Rosebud drainage.

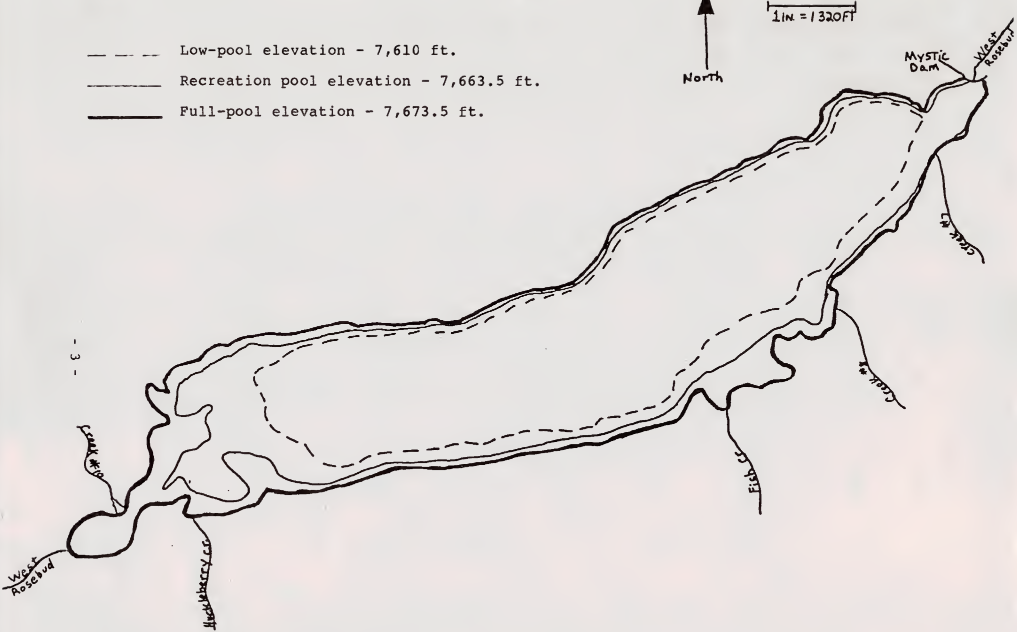

Figure 2. Map of the Study Area in Mystic Lake, 1983 and 1984.

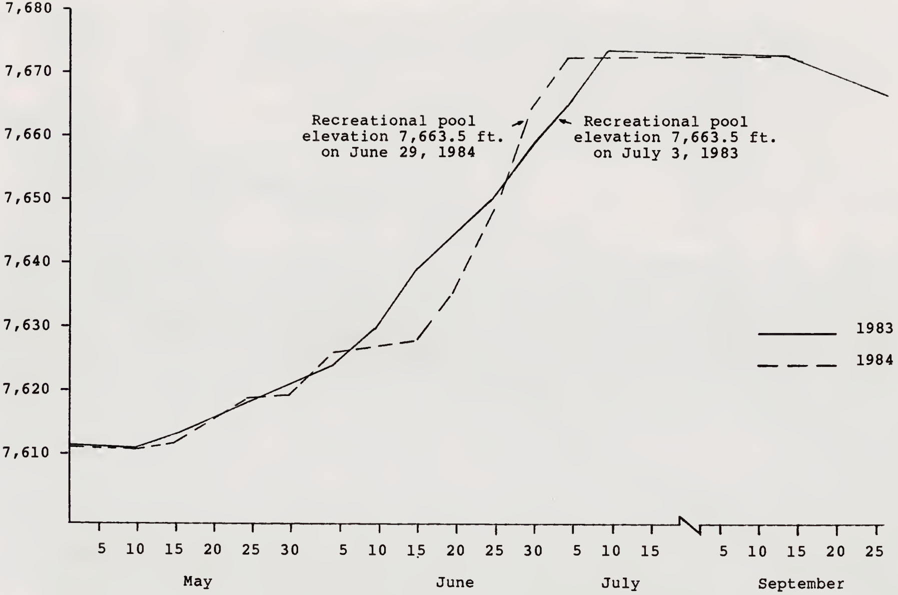

Figure 3. Daily Lake elevations in Mystic Lake from May 1 to September 25, 1983 and 1984.

63.5 ft. depth (pers. comm., Mystic dam operator). Low pool normally occurs in April at 297.85 surface acres (elevation 7,610 ft.) and remains at this level until spring runoff begins filling the lake in May. Recreational pool elevation occurs at 7,663.5 ft., and is the minimum lake elevation required by MPC's FERC license between July 1 and September 15. Lake elevation during this time period may fluctuate 10 ft. between recreational pool and full pool. Full pool generally occurs in late July. For purposes of this study, low pool refers to lake elevation prior to attainment of the recreational pool.

Tributaries draining into Mystic Lake include West Rosebud, Fish, Huckleberry and three unnamed creeks. (Marcuson 1976) assigned identification numbers 7, 8 and 10 to the three unnamed creeks in the study area. The study area includes Mystic Lake and its tributaries between low- and full-pool elevations.

METHODS

The same methods were used in 1983 and 1984 to evaluate impacts on the rainbow trout fishery associated with the attainment of the recreational pool. Daily lake elevations, supplied by Mystic dam operators, along with extensive photographs of the lake and tributary inlets were also used to document lake elevations during the spawning period. A staff guage marked at 1-foot intervals was placed in the West Rosebud full-pool inlet to document changes in lake elevation in this spawning area.

Rainbow Trout Spawning

In most streams, redds are easy to observe and count due to their cleaned appearance. The relatively sediment-free substrate of the tributaries in the study area prohibited actual redd counts in this area. To assess the use of a spawning area, fish numbers were visually counted once a week in tributaries and their inlets throughout the spawning period. Percent use of a spawning area was computed, based on the total number of spawners observed in all spawning areas. This method was successful in determining access into spawning areas. However, fish numbers observed (once a week) represent the minimum number of spawners using a spawning area. Weekly kick-sampling in the gravel with a net throughout the incubation period eventually revealed "eyed eggs" which were helpful in back-calculating when eggs were deposited and the initiation of the spawning period. The end of the spawning period was determined by noting a decrease in fish numbers observed in spawning areas.

Fish were sampled either by hook and line or gill nets. All fish sampled were weighed and measured, and sex ratio between males and females determined. Scale samples were obtained to determine the age structure of the population.

Spawning Area Micro-habitat

Intergravel dissolved oxygen (D.O.) samples were obtained in all spawning areas, using the method developed by DFWP fisheries biolgists on Flathead Lake, Montana (Decker-Hess and Graham, 1982). Intergravel samples were collected, using a hand-operated rotary pump which was connected to an 18-in. long probe of 1/8-in. galvanized pipe by 1/4-in. ID plastic tubing (Figure 4). The probe was passed through a 5-in.^{2} foam rubber-backed steel plate before it was driven into the gravel to prevent contamination of the sample by lake

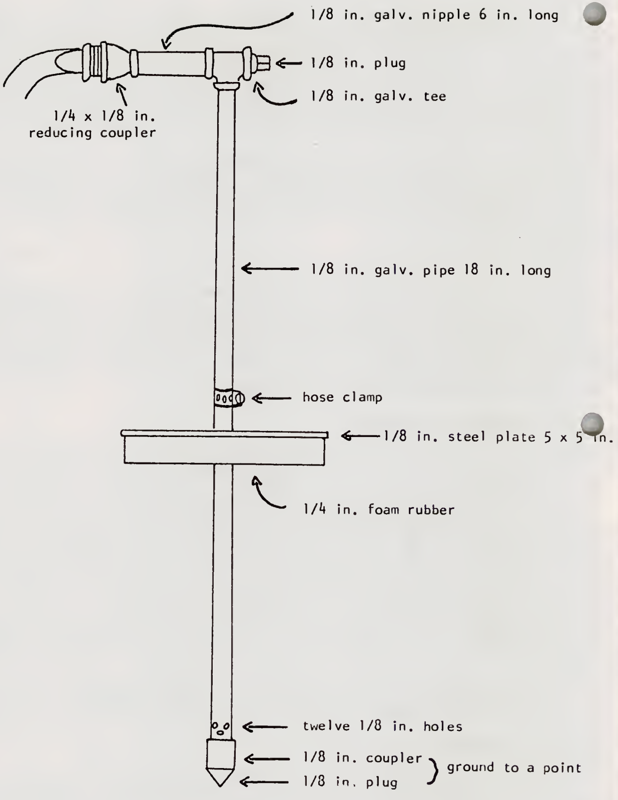

Figure 4. Dimensions of the probe used for collecting intergravel water samples in rainbow trout spawning areas (from Decker-Hess and Graham, 1982).

water. All samples were pumped into 325 ml. B.O.D. bottles. When necessary, the probe was inserted into the gravel by a SCUBA diver, while a second person operated the pump and performed the D.O. test from the boat. The modified Winkler method was used to analyze samples in the field (EPA, 1974).

D.O. in intergravel water tends to decrease with depth in the substrate (Chambers, et al., 1955; Meekin, 1967; Sheridan, 1962 and Decker-Hess, 1982). Intergravel D.O. samples were collected at the gravel surface and at 6 in. into the gravel. The intent of the sampling was to determine the depths at which dissolved oxygen became insufficient in the egg depositional area.

Rainbow Trout Egg Development

In addition to duplicating the 1983 methods, egg incubation stations were established in 1984 to determine the length of the incubation period and evaluate the hatching success in two spawning areas: West Rosebud full-pool inlet and the confluence area of Huckleberry and West Rosebud creeks. Establishment of egg incubation stations was prompted by sufficient D.O. concentrations found in the Huckleberry-West Rosebud spawning area in 1983 when the area was under 25 ft. of lake water during the incubation period. Lake elevation records show rising lake water floods the Huckleberry-West Rosebud confluence during the spawning period every year. In 1983, 20.5% of the observed spawning fish constructed redds in the area, but it was not known if egg development continued once the area was flooded. It was felt that results from the egg incubation stations established in 1984 would indicate the relative hatching success of past and future years.

Rainbow trout were captured on June 20, 1984 and artificially spawned. The fertilized eggs were placed in nylon screen bags. Each screen bag contained 30 eggs, mixed with gravel, and were buried 2-4 in. in the substrate. Three egg incubation stations were established in both the West Rosebud full-pool inlet, to be used as a control, and in the Huckleberry-West Rosebud confluence area. At each station there were two screen bags of 60 eggs. At two of the stations, the screens were sealed shut so hatching fry couldn't escape. Screen bags at the third station were not sealed, so fry could escape when they reached the button-up stage of development. Fry traps were placed over the open screen bags to capture emerging fry. The fry traps were constructed from 25-gallon barrels with a screened lid on one end and open on the opposite end. A screen fyke inside the barrel funneled the emerging fry into the compartment formed by the screen lid and funnel (Figure 5). The open end of the barrel was placed over the unsealed screen bag. Intergravel D.O. samples were obtained at each station once a week prior to planting the egg bags. Once the eggs were planted in the substrate, weekly D.O. testing continued throughout the egg development and button-up period to note any change in the D.O. associated with rising lake elevations. Water temperature was recorded at the substrate surface when intergravel D.O. samples were obtained. Water temperatures were also recorded in all tributaries in 1983 and 1984, approximately every third day to monitor the effect of temperature on rainbow selection of and movement into tributaries to spawn.

Zookplankton Development

Vertical zooplankton samples were collected on a weekly basis to follow the development sequence of the larger species: *D. shoshoni*, a copepod, and

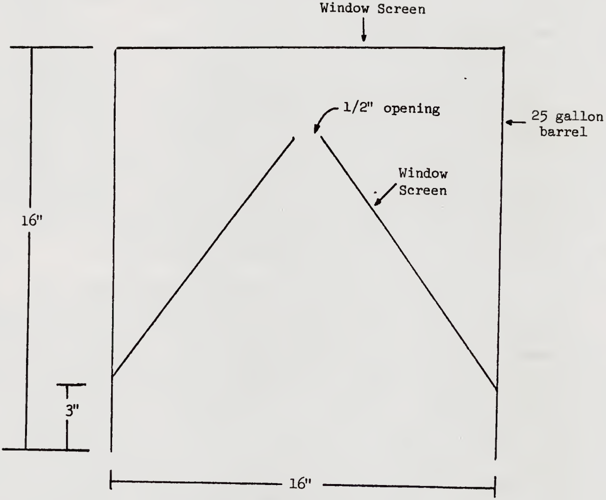

Figure 5. Dimensions of deep water fry emergence traps.

H. gibberum, a cladoceran. Quantitative sampling was not done for two reasons: 1) the early developmental stages of copepods (termed nauplii of which there are several stages) and juvenile cladocerans are extremely difficult to identify and 2) the relative abundance and specific timing of maximum and minimum populations vary considerably within a species in the same lake from one year to the next (Pennak, 1978). Because of this, quantitative differences in zooplankton development between 1983 and 1984 could not necessarily be related to lake level changes. The adult forms of the two species were relatively easy to identify, due to their large size - 2.0-2.6 mm. When adult forms first appeared in the samples, the end of the development cycle was calculated based on the date of the sample.

Rainbow Trout Diets

All stomach samples were obtained from fish captured in gill nets. During the 1983 and 1984 study period, a gill net was set overnight in the area of the West Rosebud low-pool inlet (Figure 6). Nets were set in late June, during the spawning period, in mid-July after the recreation and full-pool elevations were achieved and in late August, one month after the fish returned to their lentic environment.

In 1983, stomach contents were enumerated and percent occurrence of the dominant food item in each stomach was calculated. The food item with the highest percent occurrence was considered to be the dominant food item. A more accurate method of analyzing stomach contents, the index of relative importance (IRI), was used in 1984. The IRI is the arithmetic mean (expressed as percentages) of the number, frequency of occurrence and volume of food item in the diet (George and Hadley, 1979; Leathe and Graham, 1982). The IRI ranges from zero to 100 with the latter value indicating exclusive use of a food item. Stomach contents from 1983 were reevaluated, using the IRI in order to compare the 1983 and 1984 results. Aquatic insects found in stomachs were keyed to their taxanomic order. Zooplankton developmental stages were identified as copepod nauplii or juvenile cladocerans. The two larger zooplankton species were identified, depending on their digestive state, and grouped together as adult zooplankton.

RESULTS

Rainbow Spawning

The annual study periods began on June 15, 1983 and June 8, 1984 when the lake elevations were 7,639.89 ft. and 7,626.08 ft., respectively. During the rainbow trout spawning period, lake elevations increased 23.61 ft. in 1983 and 36.05 ft. in 1984 before reaching the recreation pool level of 7,663.5 ft. In 1983, the recreation pool occurred on July 3, 7 days before the July 10 refill date. The recreation pool in 1984 occurred on June 29, 2 days prior to the July 1 refill date. There was a 4-day difference in attaining the recreation pool elevation between 1983 and 1984.

Spawning rainbow trout were confronted with the same low-pool water conditions during both spawning periods. Before achieving the recreational pool elevation, all tributaries were carving their channels through the exposed lake bed before entering the lake. Fish were observed spawning in some of these creek channels while the lake was filling. Major spawning areas

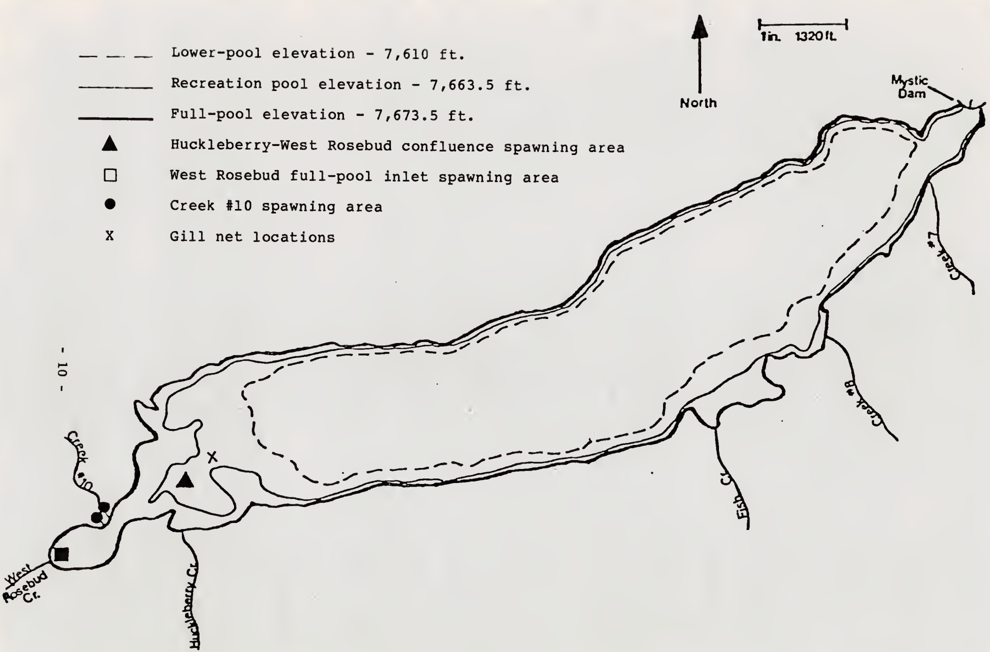

Figure 6. Location of spawning areas and gill net sets in Mystic Lake in 1983 and 1984.

were at the west end of the lake in the West Rosebud full-pool inlet, in Creek #10 above the full-pool elevation, and in the low-pool confluence area of Huckleberry and West Rosebud creeks (Figure 6).

Spawning activity in Creeks #7, #8 and Fish Creek was negligible during both the 1983-1984 spawning period. At low-pool elevations between 7,639.89 ft. and 7,648.22 ft. (June 15-June 23, 1983) and 7,626.08 ft. and 7,648.34 ft. (June 8-June 25, 1984), the inlets of these tributaries tumbled down steep, exposed shoal areas, making fish movement into them difficult. After June 23, 1983 and June 25, 1984, access improved and suitable spawning substrate existed in the exposed lake bed, but no fish were observed in these low-pool creek channels. Spawning habitat above the full-pool elevation was scarce. Cold water temperatures may have discouraged spawniing activity in these tributaries (Table 1). The optimum water temperature needed to induce rainbow to spawn lies between 50 and 55^{o} F (Piper et al. 1982). The average monthly water temperature in all tributaries was similar in 1983 and 1984. In both study periods, Creeks #7, #8 and Fish Creek averaged approximately 10 and 5^{o} F cooler than West Rosebud and Creek #10, respectively, due to their glacial origin and shaded north exposure. The influence of Island Lake and the eastern exposure of West Rosebud Creek account for the optimum spawning water temperatures found there.

Table 1. Average monthly water temperatures in Mystic Lake tributaries, 1983 and 1984.

Location	Avg. Water Temp. (^{o} F) 1983		Avg. Water Temp. (^{o} F) 1984	
	June	July	June	July
Creek #7	39	41	40	41
Creek #8	39	42	40	41
Fish Creek	40	42	40	42
Huckleberry Cr.	44	49	43	47
Creek #10	44	47	43	45
W. Rosebud Cr.	50	52	49	53

Percent use of spawning areas and the duration of the spawning period was similar in 1983 and 1984. Weekly counts of individual and paired fish observed are summarized in Tables 2 and 3. Fifty-five percent of the total observed spawners utilized West Rosebud full-pool inlet in 1983 compared to 61% in 1984. Twenty-four and 21% of the spawners were observed in Creek #10 in 1983 and 1984, respectively. Spawning fish were observed in early to mid-

Table 2. Visual observation of fish during weekly fish counts in three rainbow trout spawning areas at Mystic Lake during 1983.

Date	Paired Spawners	No. of Fish	No. of Unpaired Fish	Total No. of Fish
		West Rosebud Creek Full-pool Inlet		
6/15	66	132	53	185
6/24	62	124	56	180
7/1	71	142	48	190
7/7	59	118	42	160
7/14*	-	-	-	-
7/21	7	14	21	35
Total	265	530	220	750
		Creek #10		
6/16**	-	-	-	-
6/24	35	70	45	115
7/1	41	82	39	105
7/7	11	22	24	46
7/14	4	8	19	27
7/21***			21	21
Total	91	182	148	320
		Huckleberry-West Rosebud Creek Confluence		
6/16	13	26	21	47
6/23	61	122	16	158
6/24	31	62	13	75
6/28***	-	-	-	-
Total	105	210	50	280

*Turbid water made it difficult to accurately count fish.

**Fish were not counted until June 24.

***Spawning area inundated with lake water.

Table 3. Visual observation of fish during weekly fish counts in three rainbow trout spawning areas at Mystic Lake during 1984.

Date	Paired Spawners	No. of Fish	No. of Unpaired Fish	Total No. of Fish
		West Rosebud Full-pool Inlet		
	66	132	50	182
6/15	51	102	42	144
6/22	44	88	59	147
7/1	46	92	35	127
7/9	18	36	28	64
7/21	0	0	38	38
Total	225	450	252	702
		Creek #10		
6/8	6	12	12	24
6/15	16	32	19	51
6/22	21	42	30	72
7/1	13	26	20	46
7/9	7	14	18	32
7/21	1	2	14	16
Total	64	128	113	241
		Huckleberry-West Rosebud Creek Confluence		
6/8	15	30	28	58
6/15	26	52	30	82
6/22	20	40	28	68
6/26*	-	-	-	-
Total	61	122	86	208

*Spawning area inundated with lake water.

June during both spawning periods in the West Rosebud full-pool inlet and in Creek #10. Fish numbers declined in early July when spring runoff had increased in 1983 and 1984.

The confluence of Huckleberry and West Rosebud creeks was approximately 15 ft. below the recreation pool elevation in 1983 and 1984 prior to initial flooding. In 1983, 20.5% of the spawners used this area to construct redds and 18% spawned there in 1984. Spawning fish were not observed after June 26 when the area was flooded with an additional 2.78 ft. of water in 1983 (total water depth 4.03 ft.) and 1.87 ft. in 1984 (total water depth 3.12 ft.). Initial flooding of this area occurred on June 25 in both years regardless of the July 1 or July 10 recreational pool deadline.

A total of 217 fish were sampled by gill nets and hook and line during 1983 and 1984; 96.3% were rainbow trout and 3.7% appeared to be rainbow-cutthroat hybrids. The average size was 9.9 in. in 1983 and 10.5 in. in 1984. The combined average was 10.2 in. There were 1.7 females to every male.

The age structure of all fish sampled in both years is summarized in Table 4. Sample size ranged from 6.0 inches (Age II) to 14.2 inches (Age IV+). Gill nets were inefficient at capturing smaller Age I fish. Age II fish ranged from 6.0 to 8.5 inches, averaging 7.0 inches. Size range of Age III fish was from 7.9 to 10.1 inches and averaged 9.4 inches. Age IV and IV+ fish lengths ranged from 9.0-11.3 inches and 10.6-13.6 inches, averaging 10.3 and 12.0 inches, respectively.

Table 4. Rainbow trout age structure in Mystic Lake.

Age Class	Size Ranges (inches)	Avg. Length (inches)	Avg. Weight (lb.)
I	-	-	-
II	6.0- 8.5	7.0	.14
III	7.9-10.1	9.4	.23
IV	9.0-11.3	10.3	.35
IV+	10.6-13.6	12.2	.50

Spawning Area Microhabitat

Attainment of the recreational pool elevation on July 3, 1983 and June 28, 1984 did not affect the water level in the West Rosebud full-pool inlet (Table 5). This area was flooded with 1.8 ft. of rising lake water on July 9, 1983 and July 3, 1984 with 1 foot of water. Maximum elevation occurred on July 21 in both years.

Table 5. Water depths (in ft.) in the West Rosebud full-pool inlet spawning area during the spawning and incubation period in 1983 and 1984.

Date	West Rosebud Full-pool Inlet 1983	1984
6/8	-	0.8
6/15	1.0	1.0
6/24	1.0	1.0
6/25	1.0	1.0
6/26	1.0	1.0
6/28	1.0	1.0
7/1	1.0	1.0
7/2	1.0	1.0
7/3	1.0	2.0
7/4	1.0	2.0
7/9	2.8	2.5
7.13	2.5	-
7/21	3.5	2.7
8/3	3.0	2.5
8/27	2.5	2.5
8/29	2.0	-

Spawning sites in the Huckleberry-West Rosebud confluence were flooded with rising lake water before the recreation pool was achieved in 1983 and 1984. Initial flooding in this area occurred on June 25 in both years, raising the water depth .81 ft. in 1983 and .22 ft. in 1984. However, the rate of flooding differed in both study years between June 25 and attainment of the recreational pool elevation (Table 6). Once this area began flooding, it took 9 days to reach the recreation pool in 1983, averaging 1.62 ft./day, and 5 days in 1984, averaging 3.14 ft./day. Maximum water depth over this area was 25.6 ft. on July 10, 1983 and 24.78 feet on July 23, 1984.

Results of intergravel D.O. samples are summarized in Tables 7 and 8. Rainbow trout eggs require a mimimum of 5 mg/l or greater of D.O. to develop. Without sufficient oxygen, eggs develop abnormalities, and their hatching may be delayed or premature (Piper et al. 1982). Intergravel D.O. samples collected at the three stations in West Rosebud full-pool inlet and in the confluence area of Huckleberry and West Rosebud creeks satisfied the 5 mg/l minimum required for healthy egg development at the substrate surface and 6 in. beneath the substrate. The D.O. at 10 in. into the substrate in both spawning areas was insufficient for egg development.

In the West Rosebud full-pool inlet, dissolved oxygen samples from the substrate surface ranged from 8.2 to 8.8 mg/l on June 13, 1984 (water temperature 50^{o} F) and later decreased to 7.6 mg/l (59^{o} F) by August 8. The D.O. 6 in. beneath the substrate initially ranged from 6.4-7.6 mg/l and decreased to 4.0-4.6 mg/l.

Table 6. Daily water depth (in feet) in the Huckleberry-West Rosebud Confluence spawning area between June 25 and attainment of the recreational pool elevation in 1983 and 1984.

Date	Water Depth in the Huckleberry-West Rosebud Confluence 1983	1984
6/24	1.25*	1.25*
6/25	2.06	1.47
6/26	4.03	3.12
6/27	5.98	6.32
6/28	7.99	10.27
6/29	9.60	13.82**
6/30	10.87	16.83
7/1	12.12	20.15
7/2	13.2	22.85
7/3	15.43**	23.84
7/4	16.48	23.96
7/5	17.29	24.04
7/6	18.15	24.11
7/7	20.03	24.17
7/8	20.57	24.48
7/9	24.63	24.40
7/10	25.60	24.18

*Water depth prior to flooding.

**Date recreation pool achieved.

Table 7. Intergravel dissolved oxygen concentrations (mg/l) at three stations in the West Rosebud full-pool inlet, 1984.

Date	Water Temperature (^{O} F) at Substrate Surface	Probe Depth (in.)	Dissolved Oxygen Concentration (mg/l) Upper Station	Middle Station	Lower Station
6/8	49	-	-	-	-
6/13	50	0	8.2	8.6	8.8
		6	7.6	6.4	7.2
		8	6.0	6.0	6.4
6/21	49	0	8.2	9.2	8.8
		6	7.4	7.4	7.0
		8	5.2	6.6	6.0
6/28	50	0	7.4	8.0	7.8
		6	7.0	7.0	6.6
		8	5.6	6.0	5.8
7/9	43	0	8.2	7.6	7.8
		6	7.4	7.0	6.8
		8	6.8	6.0	6.0
7/20	58	0	7.6	8.6	7.6
		6	6.2	7.0	6.0
		8	-	-	-
7/24	58	0	9.2	8.8	8.8
		6	5.6	5.6	6.0
		8	4.2	4.8	5.6
8/3	58	0	7.6	7.6	8.0
		6	5.6	5.0	5.6
		8	3.8	3.8	3.6
8/8	59	0	7.6	7.6	7.6
		6	4.6	4.0	4.1
		8	3.6	3.9	3.7
8/13	60	0	6.6	6.6	6.6
		6	2.6	3.0	2.6
		8	2.0	1.4	2.2

Table 8. Intergravel dissolved oxygen concentrations (mg/l) at three stations in the Huckleberry-West Rosebud confluence area, 1984.

Date	Water Temperature (^{O} F) at Substrate Surface	Probe Depth (in.)	Dissolved Oxygen Concentration (mg/l) Upper Station	Middle Station	Lower Station
6/8	47	-	-	-	-
6/13	50	0	8.7	8.6	8.7
		6	8.8	8.0	8.2
		8	6.8	7.0	6.9
6/21	47	0	8.8	8.8	8.8
		6	8.6	7.6	8.2
		8	6.9	7.2	7.0
6/8	-	0	-	-	-
		6	-	-	-
		8	-	-	-
7/9	40	0	7.0	7.0	7.0
		6	6.6	6.7	6.4
		8	6.0	6.1	6.0
7/20	54	0	6.6	7.2	7.2
		6	6.2	6.2	6.1
		8	6.0	6.0	5.9
7/24	49	0	7.2	7.0	7.1
		6	6.0	6.3	5.9
		8	5.2	5.1	4.6
8/3	56	0	7.2	7.2	7.2
		6	6.6	6.4	4.8
		8	5.1	5.0	4.5
8/8	56	0	7.2	7.2	7.2
		6	5.1	5.0	5.0
		8	4.2	4.2	4.0
8/13	56	0	7.2	7.2	8.8
		6	3.6	4.5	2.4
		8	3.2	4.2	2.0

During the same sampling period, the D.O. at the substrate surface in the Huckleberry-West Rosebud confluence was 8.7 mg/l, decreasing to 7.2 mg/l when the area was under 24.5 ft. of water. Samples collected 6 in. into the substrate ranged from 8.0-8.8 mg/l initially, and decreased to 5.0 mg/l. Water temperature at the substrate surface during the sampling period increased from 40 to 56^{o} F.

Rainbow Trout Egg Development

Hatching of rainbow trout eggs placed in screen bags occurred in both the West Rosebud full-pool inlet and the confluence of Huckleberry and West Rosebud creeks. Fry traps, however, were inefficient at capturing emerging fry in both spawning areas.

Rainbow trout eggs hatch in 48 days when water temperature is 45^{o} F, 31 days at 50^{o} and 24 days at 55^{o} F (Piper, et al., 1982). The incubation period in the West Rosebud full-pool inlet was approximately 34 days. Water temperature fluctuated from 47 to 58^{o} F, averaging 52^{o} F. Egg bags were pulled from each of the three stations in both spawning areas on July 24. Sac fry were present only in the West Rosebud full-pool inlet. Sixty percent of the eggs from the combined lower and middle stations in the West Rosebud full-pool inlet either hatched or were well developed in the "eyed stage" (hatching was imminent). Twenty percent of the eggs hatched in the upper station. Low hatching success at the upper station may have resulted from a disturbance at this site in late June (one of the egg bags and the stake marking its location was found along the shoreline).

After hatching, sac fry remain in the substrate until their yolk sac is absorbed or "buttoned up" before emerging. Four fry out of 180 eggs were observed in traps 15 days after hatching in the West Rosebud full-pool inlet. Sixty-six dead eggs remained and 110 eggs were missing, indicating these eggs hatched and the fry eluded the traps. Traps were not placed in Creek #10 because redds were located above the full-pool inlet and were not affected by rising lake water. However, the incubation period was delayed slightly, due to the cooler water found there. Fry were observed at the inlet of Creek #10 in late August.

Rainbow eggs in the confluence area of Huckleberry and West Rosebud creeks required a longer incubation period. On July 24, only one egg bag was pulled from each station. There was 100% egg mortality at the lower station. Twenty percent of the eggs from the middle and upper stations were at the eyed stage. The remaining egg bags were pulled 10 days later, and 23% of the combined eggs in the middle and upper stations hatched. There was 100% mortality at the lower station. The incubation period was approximately 44 days, 10 days longer than in the West Rosebud full-pool inlet. Water temperature fluctuated from 47 to 54^{o} F, averaging 49^{o} F. Only 1 fry out of 120 eggs was captured in the fry traps. There were 79 dead eggs at both middle and upper stations and 41 eggs were missing.

Zooplankton Development

Timing of the large zooplankton development in Mystic Lake differed in 1983 and 1984. Copepod nauplii and juvenile cladocerans were observed in 1983 from late June to mid-July. By mid-July, adult forms of *D. gibberum* appeared

in vertical plankton tows. Nauplii and juveniles were not present in late July samples.

In 1984, D. shoshoni and H. gibberum were first observed in late June approximately 2 weeks earlier than in 1983. Early developmental stages of both copepods and cladocerans were also present. In mid-July, the adult forms of both species predominated the sample.

Rainbow Trout Diets

A total of 137 stomach samples were examined, 90 in 1983 and 47 in 1984. Their contents are summarized in Appendix A tables 1-6.

Aquatic and semi-aquatic insects were the preferred food item in June of both years when fish were in tributary streams selecting spawning sites. Diptera larvae were the dominant food item in 1983 and 1984 (Figures 7 and 8). Other food groups in order of importance in 1983 were Trichoptera larvae, Coleoptera adults, Hymenoptera adults, Plecoptera nymphs, copepod nauplii and juvenile cladocerans, Diptera pupae and Ephemeraptera nymphs. Food groups in order of importance in 1984 were Hymenoptera adults, Coleoptera adults, Diptera pupae, Ephemeraptera numphs, Trichoptera nymphs and Diptera adults.

In mid-July, Diptera larvae and pupae were the dominant food item. Copepod nauplii and juvenile cladocerans along with adult forms were observed in 1983. In 1984, only adult zooplankton were present in mid-July. By late August when rainbow were distributed throughout the lake, adult zooplankton was the dominant food item.

DISCUSSION AND CONCLUSIONS

Three major rainbow trout spawning areas were located at the west end of Mystic Lake: in the West Rosebud full-pool inlet, in Creek #10 above the full-pool elevation and in the low-pool confluence area of Huckleberry and West Rosebud creeks. Trout movement into these spawning areas was not affected by the refill of Mystic Lake in 1983. Spawning rainbow were confronted with equal low-pool water conditions and subsequent rising water levels as the lake approached the recreational pool elevation in 1983 and 1984. Use of all three spawning areas was similar in both years. Attainment of the recreation pool did not affect water levels in the West Rosebud full-pool inlet and in Creek #10 spawning areas. Access into these areas was adequate in both years. The Huckleberry-West Rosebud confluence area was inundated with lake water before the recreational pool was attained in 1983 and 1984. Despite flooding in this area, 23% of the rainbow trout eggs in the egg incubation stations hatched. Observed spawners imprinting on this spawning area implies that rainbow trout eggs deposited there in the past have developed and hatched.

At present, the rainbow population in Mystic Lake is abundant and self-sustaining, indicating past operation of the Mystic Power Plant has not threatened the fishery. A reservoir regulation study by MPC (based on 50 years of record) found the proposed July 10 refill deadline would have affected the lake level on July 1 in 19 years out of the 50 years of study (randomly distributed), and there would have been no effect on the lake level on July 1 in 31 of the 50 years of study (pers. comm. Frank Pickett, MPC,

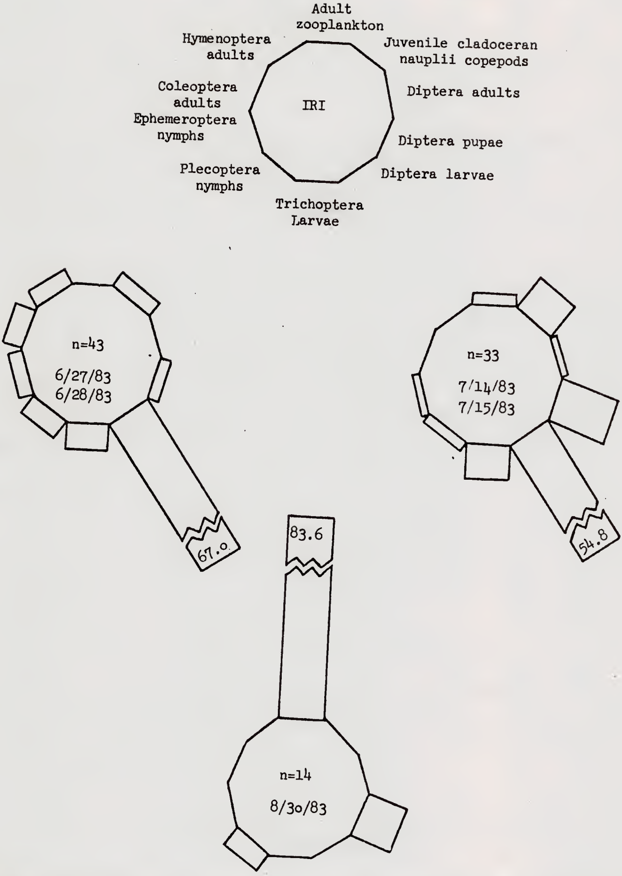

Figure 7. Index of relative importance (IRI) of food items found in rainbow trout stomachs in Mystic Lake in 1983.

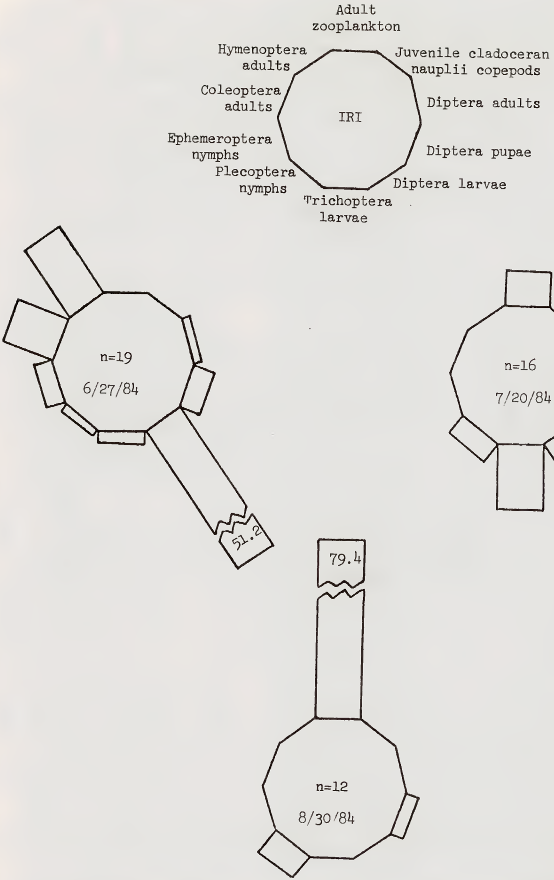

Figure 8. Index of relative importance (IRI) of food items found in rainbow trout stomachs in Mystic Lake in 1984.

1983). The average refill date would have occurred on July 6 during the affected years. Refill would have been delayed the maximum 10 days to July 10 in four out of the 50 years of study. The MPC reservoir regulation study and the fisheries data presented in this report indicates the extension of MPC's FERC license from July 1 to July 10 would not have a significant impact on the rainbow trout fishery in Mystic Lake.

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Appendix A

Rainbow Trout Diet Information

Table 1. Composition by number, volume, frequency of occurrence and calculated index of relative importance (IRI) for major food items in 43 rainbow trout stomachs collected on June 27 and 28, 1983.

Food Item	No.	(%)	Vol. (ml)	(%)	Freq. of Occur.	(%)	IRI
Diptera (pupae)	14	(1.4)	.1	(1.2)	3	(5.9)	2.8
Diptera (larvae)	789	(81.1)	5.1	(59.0)	31	(61.0)	67.0
Trichoptera (larvae)	66	(6.8)	.6	(7.0)	5	(9.8)	7.8
Plecoptera (nymphs)	29	(3.0)	.2	(.23)	5	(9.8)	4.3
Ephemereptera (nymphs)	10	(1.0)	.1	(1.2)	3	(5.9)	2.7
Copepod nauplii and juvenile cladocerans	52	(5.3)	>.1	(>1.2)	2	(3.8)	3.4
Hymenoptera (adults)	6	(.62)	.1	(11.5)	1	(1.9)	4.6
Coleoptera (adults)	7	(.72)	1.5	(17.2)	1	(1.9)	6.54
Total	937		8.7		51		
Insect parts*			1.5		38		
Debris*			2.0		5		

*Not included in total.

Table 2. Composition by number, volume, frequency of occurrence and calculated index of relative importance (IRI) for major food items in 33 rainbow trout stomachs collected on July 14 and 15, 1983.

Food Item	No.	(%)	Vol. (ml)	(%)	Freq. of Occur.	(%)	IRI
Diptera (adults)	2	(.2)	>.1	(1.8)	1	(1.9)	1.3
Dipters (pupae)	69	(8.4)	.4	(7.4)	17	(32.7)	16.2
Diptera (larvae)	466	(57.0)	3.5	(65.0)	22	(42.3)	54.8
Trichoptera (larvae)	79	(9.6)	.8	(14.8)	3	(5.8)	10.1
Plecoptera (nymphs)	8	(.9)	.1	(1.8)	3	(5.8)	2.8
Ephemeroptera (nymphs)	22	(2.7)	.2	(3.7)	1	(1.9)	2.8
Copepad nauplii and juvenile cladoceran	170	(20.8)	.2	(3.7)	3	(5.8)	10.1
Adult zooplankton	3	(.4)	>.1	(1.8)	2	(3.8)	2.0
Total	819		5.4		52		
Insect parts*			4.0		19		
Debris*			2.0		4		

*Not included in total.

Table 3. Composition by number, volume, frequency of occurrence and calculated index of relative importance (IRI) for major food items in 14 rainbow trout stomachs collected on August 30, 1983.

Food Item	No.	(%)	Vol. (ml)	(%)	Freq. of Occur.	(%)	IRI
Zooplankton (adult)	1,566	(98.3)	1.0	(83.3)	9	(69.2)	83.6
Diptera (pupae)	20	(1.3)	.1	(8.3)	3	(23.1)	10.9
Plecoptera (adult)	7	(.40)	.1	(8.3)	1	(7.7)	5.5
Total	1,593		1.2		13		
Insect parts*			>.1		2		
Debris*			.1		1		

*Not included in total.

Table 4. Composition by number, volume, frequency of occurrence and calculated index of relative importance (IRI) for major food items in 19 rainbow trout stomachs collected on June 27, 1984.

Food Item	No.	(%)	Vol. (ml)	(%)	Freq. of Occur.	(%)	IRI
Diptera (adults)	2	(.2)	>.1	(>.73)	1	(2.2)	1.04
Diptera (pupae)	15	(1.8)	.10	(.73)	7	(16.0)	6.2
Diptera (larvae)	676	(82.0)	4.50	(33.1)	17	(39.0)	51.2
Trichoptera (larvae)	3	(.4)	>.1	(>.73)	3	(7.0)	2.71
Plecoptera (nymphs)	2	(.2)	>.1	(>.73)	2	(5.0)	2.0
Epheneroptera (nymphs)	12	(1.4)	.20	(1.5)	5	(11.4)	4.8
Hymenoptera (adults)	63	(7.6)	5.50	(40.4)	4	(9.0)	19.0
Coleoptera (adults)	55	(6.6)	3.0	(22.1)	5	(11.4)	13.6
Total	888		13.6		44		
Insect parts			5.0		14		
Debris			1.5		11		
					25		

Table 5. Composition by number, volume, frequency of occurrence and calculated index of relative importance (IRI) for major food items in 16 rainbow trout stomachs collected on July 20, 1984.

Food Item	No.	(%)	Vol. (ml)	(%)	Freq. of Occur.	(%)	IRI
Diptera (adults)	1	(.4)	.10	(4.7)	1	(3.3)	2.8
Diptera (pupae)	131	(54.1)	1.0	(47.6)	10	(33.3)	45.0
Diptera (larvae)	47	(19.4)	.25	(11.8)	9	(30.0)	20.4
Trichoptera (larvae)	34	(14.0)	.40	(19.0)	6	(30.0)	17.6
Plecoptera (nymphs)	2	(.8)	.20	(9.5)	2	(6.6)	5.6
Zooplankton (adult)	27	(11.1)	.20	(9.5)	2	(6.6)	9.0
Total	242		2.1		30		
Insect parts*			5.5		14		
Debris*			.20		7		

*Not included in total.

Table 6. Composition by number, volume, frequency of occurrence and calculated index of relative importance (IRI) for major food items in 12 rainbow trout stomachs collected on August 27, 1984.

Food Item	No.	(%)	Vol. (ml)	(%)	Freq. of Occur.	(%)	IRI
Zooplankton (adult)	3,462	(99.8)	2	(65.0)	11	(73.3)	79.4
Diptera (pupae)	1	(.02)	>.1	(3.0)	1	(6.6)	3.2
Plecoptera (adult)	3	(.09)	.5	(16.0)	1	(6.6)	7.6
Total	3,466		3.1		15		
Insect parts*			.1		2		

*Not included in total.